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Docket No. MXICP012

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Appellant: Chin-Ta Su
Serial No.: 10/719,759 Examiner: McDonald, Rodney Glenn
Confirmation No: 3129 Group Art Unit: 1753
Filing Date: 11/20/2003
Title: METHOD OF IMPROVING THERMAL STABILITY FOR
COBALT SALICIDE

CERTIFICATE OF MAILING

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MAIL STOP APPEAL BRIEF – PATENTS
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Sir:

APPEAL BRIEF

Appellant submits this Appeal Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner dated September 7, 2007, finally rejecting claims 1, 2, 6-8, 12, 13, and 17 (Appellant filed a Notice of Appeal on December 7, 2007). The fee of \$510.00 for filing this brief under 37 CFR 41.20(b)(2) is enclosed herewith.

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Application No. 10/719,759
Appeal Brief

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D) REAL PARTY IN INTEREST

The real party in interest is Macronix International Co., Ltd, located in Hsinchu, Taiwan, which is the assignee of this patent application.

II) RELATED APPEALS AND INTERFERENCES

The Appellant knows of no related appeals or interferences that might directly effect or be directly effected by or have bearing on the Board's decision in the pending appeal.

III) STATUS OF CLAIMS

All pending claims 1, 2, 6-8, 12, 13, and 17 have been finally rejected and are subject to the present appeal. Claims 3-5, 9-11, and 14-16 were canceled during prosecution.

IV) STATUS OF AMENDMENTS

No amendment has been made after the Final Office Action.

V) SUMMARY OF CLAIMED SUBJECT MATTER

For the purpose of this appeal brief only, the claimed subject matter will be explained herein below with references to the specification by page and line number, and to the drawings by reference characters.

Independent **Claim 1** is directed to a method of improving a thermal stability for cobalt salicide (150, FIG. 4), comprising:

providing a substrate having a silicon layer thereon; (152, FIG. 4; page 8, lines 23-25)

forming a cobalt layer over the silicon layer; (154, FIG. 4; page 9, lines 9-13)

forming a TiN_x layer over the cobalt layer; (156, FIG. 4; page 9, lines 14-25)

performing a first thermal process to form a cobalt salicide layer over the silicon layer, the performing of the first thermal process including: (158, FIG. 4; page 10, lines 1-6)

diffusing cobalt into the silicon layer to form the cobalt salicide layer;

diffusing nitrogen in the TiN_x layer into the cobalt salicide layer; and

minimizing a diffusion of the Ti from the TiN_x layer into the silicon layer;

and

removing a non-reactive cobalt layer, (160, FIG. 4; page 10, lines 7-13)

wherein the TiN_x layer is formed by a sputtering process, a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1.

Independent **Claim 7** is directed to a method of forming cobalt salicide (150, FIG. 4), comprising:

providing a layer of silicon; (152, FIG. 4; page 8, lines 23-25)

forming a layer of cobalt over the layer of silicon; (154, FIG. 4; page 9, lines 9-13)

forming a layer of TiN_x over the layer of cobalt, wherein the TiN_x layer is formed by a sputtering process, a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1 (156, FIG. 4; page 9, lines 14-25); and

performing a first thermal process to form a cobalt salicide layer over the silicon layer(158, FIG. 4; page 10, lines 1-6), the performing of the first thermal process including:

- diffusing cobalt into the silicon layer to form the cobalt salicide layer;
- diffusing nitrogen in the TiN_x layer into the cobalt salicide layer; and
- minimizing a diffusion of the Ti from the TiN_x layer into the silicon layer.

Independent **Claim 13** is directed to a method for forming cobalt salicide having improved thermal stability(150, FIG. 4), comprising:

- providing a silicon layer, the silicon layer being one of a substrate formed of silicon and a layer of silicon formed over a substrate; (152, FIG. 4; page 8, lines 23-25)

- forming a cobalt layer over the silicon layer; (154, FIG. 4; page 9, lines 9-13)

- forming a TiN_x layer over the cobalt layer, wherein the TiN_x layer is formed by a sputtering process, a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1; (156, FIG. 4; page 9, lines 14-25)

- performing a first thermal process to form a cobalt salicide layer over the silicon layer(158, FIG. 4; page 10, lines 1-6), the performing of the first thermal process including:

- diffusing cobalt into the silicon layer to form the cobalt salicide layer;
 - diffusing nitrogen in the TiN_x layer into the cobalt salicide layer; and
 - minimizing a diffusion of the Ti from the TiN_x layer into the silicon layer;

- removing any unreacted cobalt(160, FIG. 4; page 10, lines 7-13); and

- performing a second thermal process to reduce a resistance of cobalt salicide formed in the performing of the first thermal process. (162, FIG. 4; page 10, lines 9-13)

VI) GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Claims 1, 2, 7, 8, and 13 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Giewont (US 6,388,327).

B. Claims 6, 12, and 17 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Giewont (US 6,388,327) in view of Besser (US 5,970,370).

VII) ARGUMENT

A. Claims 1, 2, 7, 8, and 13 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Giewont (US 6,388,327)

The Prior Art

Giewont

Giewont discloses a capping layer for a semiconductor structure. The capping layer is deposited over a silicide-forming metal and has a composition such that nitrogen diffusion therefrom is insufficient to cause formation of an oxynitride from an oxide layer on the underlying silicon. The capping layer may be a metal layer from which no N atom diffusion occurs, or one or more layers including Ti and/or TiN arranged so that N atoms do not reach the oxide layer. A method is also described for forming the Ti and TiN layers. It is advantageous to deposit non-stoichiometric TiN deficient in N, by sputtering from a Ti target in a nitrogen flow insufficient to cause formation of a nitride on the target. According to the disclosure which Examiner relies upon, Giewont discloses that the conventional process can be operated in the region of III in Fig.2 to produce a layer having additional nitrogen.

Besser

Besser discloses an improved process for manufacturing cobalt silicide layers uses two capping layers. A first capping layer of titanium nitride prevents the formation of a cobalt/titanium intermetallic. A subsequently formed titanium metallic layer getters impurities from outgassing and the ambient preventing corruption of the cobalt layer. Two rapid thermal annealing steps convert the cobalt at the cobalt/silicon intermetallic into highly conductive cobalt disilicide. The cobalt silicide does not suffer from linewidth dependent increases in resistivity. Therefore, the cobalt disilicide formed by the present method is useful for semiconductor devices with linewidths and feature sizes less than 0.20 .mu.m. The process has wide applicability and may be used to fabricate local circuit interconnects, floating gates, double polysilicon stacked floating gates as well as other uses. (see abstract)

Claims 1, 2, 7, 8, and 13 are patentable over Giewont for at least the following reasons.

With respect to one aspect of the claimed invention, Examiner asserts that Giewont teaches to form a titanium nitride film with excess nitrogen. The nitrogen flow can be increased above 60 sccm to achieve the claimed gas ratio. The motivation for operating with a N₂ to Ar ratio of 3:1 is that it allows formation of a film that has excess nitrogen.

It is respectfully submitted that Giewont does not disclose or teach this feature. As shown in FIG. 2 of Giewont and the related description, the Ar flow is 40 sccm and the N₂ flow is 60 sccm in the III region. Therefore Giewont discloses a ratio of N₂ to Ar in FIG.2, the ratio is less than 1.5. The ratio of N₂ to Ar of the claimed invention is approximately 3. There is no motivation for one of ordinary skill in the art to increase the ratio of N₂ to Ar from 1.5 to 3.

Giewont discloses on column 2, lines 37-56 that **the involvement of nitrogen in the cobalt silicide formation process has an undesirable effect**. Specifically, diffusion of N atoms from the TiN capping layer to the oxide layer may result in formation of an **oxynitride layer**, which **blocks diffusion of Si atoms** to the cobalt layer. A thick oxynitride may also **inhibit transport of Co atoms**. This results in **incomplete formation of the CoSi**, with a layer of unreacted Co above the oxynitride after the first anneal. This Co layer is stripped away with the TiN capping layer, leaving a thin layer of CoSi. This in turn results in a thin layer of CoSi₂ being formed in the second anneal, with discontinuities in the CoSi₂ layer. **There is therefore a need for a capping layer for the cobalt metal which in general controls the introduction of N atom into the cobalt prior to formation of the CoSi₂, and in particular avoids formation of an oxynitride between the cobalt and silicon, thereby permitting complete formation of the CoSi.**

Giewont teaches away from the present invention because the purpose of Giewont mentioned above is to **control the introduction of N atom into the cobalt prior to formation of the CoSi₂, and in particular avoid formation of an oxynitride between the cobalt and silicon.**

Giewont also teaches away in the embodiments. For example, in the description about the fifth embodiment on column 5, lines 31-43, Giewont teaches

that the capping layer of this embodiment comprises a combination of (1) a nitrogen-rich TiN layer 81 and (2) a layer 82 of pure Ti deposited thereon (FIG. 9A). Layer 81 preferably has a thickness less than about 50 angstroms, while the thickness of layer 82 is approximately 200 angstroms. The thickness of the TiN(+) film 81 is chosen to provide sufficient adhesion to the underlying Co layer without excess stress, while limiting the amount of nitrogen available to form an oxynitride in oxide layer 11. Nitrogen atoms diffusing from the TiN(+) layer 81 will be absorbed in the Ti layer 82 (see FIG. 9B), so that **less N is available to diffuse into and through the cobalt layer 2. Accordingly, formation of an oxynitride is avoided.**

One of ordinary skill in the art will follow the teaching of Giewont to avoid additional nitrogen in TiN layer. Since increasing the ratio of N₂ to Ar will increase probability of the undesirable effect mentioned by Giewont, there is no motivation for one of ordinary skill in the art to increase the ratio from 1.5 to 3.

Appellant respectfully submits that Giewont does not disclose or teach a N₂ to Ar ratio of 3:1. Giewont is silent about and lacks the claimed feature “a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1”. And it is unreasonable to state that the motivation for operating with a N₂ to Ar ratio of 3:1 is that it allows formation of a film that has excess nitrogen.

For the foregoing reasons that Giewont is silent about and lacks the claimed feature and therefore the Examiner’s rejection is unreasonable. Thus, Claims 1, 2, 7, 8, and 13 are considered allowable over the prior art references.

B. Claims 6, 12, and 17 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Giewont (US 6,388,327) in view of Besser (US 5,970,370)

The dependent Claims 6, 12, and 17 are patentable over Giewont for at least the same reasons set forth above in section A.

Further, even if Besser discloses the claimed limitation of Claims 6, 12, and 17, Besser still does not make up for the deficiency of Giewont.

Claims 6, 12, and 17 are therefore considered allowable over the prior art references.

CONCLUSION

In light of the above reasons, Appellant respectfully submits that Claims 1, 2, 6-8, 12, 13, and 17 on appeal are patentable because:

1. Giewont is silent about and lacks the claimed feature “a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1”; and

2. It is unreasonable to state that the motivation for operating with a N₂ to Ar ratio of 3:1 is that it allows formation of a film that has excess nitrogen.

If the Board agrees with any one (or both) of the statements submitted above, they should allow all the claims on appeal.

Accordingly, the reversal of the Examiner by the honorable Board of Appeals is respectfully solicited.

Respectfully submitted,
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VIII) CLAIMS APPENDIX

Claim 1:

A method of improving a thermal stability for cobalt salicide, comprising:

providing a substrate having a silicon layer thereon;

forming a cobalt layer over the silicon layer;

forming a TiN_x layer over the cobalt layer;

performing a first thermal process to form a cobalt salicide layer over the silicon layer, the performing of the first thermal process including:

diffusing cobalt into the silicon layer to form the cobalt salicide layer;

diffusing nitrogen in the TiN_x layer into the cobalt salicide layer; and

minimizing a diffusion of the Ti from the TiN_x layer into the silicon layer;

and

removing a non-reactive cobalt layer,

wherein the TiN_x layer is formed by a sputtering process, a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1.

Claim 2:

The method of claim 1, further comprising: performing a second thermal process, wherein the second thermal process is performed after the removing of the non-reactive cobalt layer.

Claim 6:

The method of claim 1, wherein the TiN_x layer is formed to a thickness in a range of approximately 25 angstroms to approximately 100 angstroms.

Claim 7:

A method of forming cobalt salicide, comprising:

providing a layer of silicon;

forming a layer of cobalt over the layer of silicon;

forming a layer of TiN_x over the layer of cobalt, wherein the TiN_x layer is formed by a sputtering process, a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1; and

performing a first thermal process to form a cobalt salicide layer over the silicon layer, the performing of the first thermal process including:

- diffusing cobalt into the silicon layer to form the cobalt salicide layer;
- diffusing nitrogen in the TiN_x layer into the cobalt salicide layer; and
- minimizing a diffusion of the Ti from the TiN_x layer into the silicon layer.

Claim 8:

The method of claim 7, further comprising:

- removing a layer of non-reactive cobalt; and
- performing a second thermal process, the second thermal process being performed to decrease a resistance of cobalt salicide formed in the performing of the first thermal process.

Claim 12:

The method of claim 1, wherein the TiN_x layer is formed to a thickness in a range of approximately 25 angstroms to approximately 100 angstroms.

Claim 13:

A method for forming cobalt salicide having improved thermal stability, comprising:

- providing a silicon layer, the silicon layer being one of a substrate formed of silicon and a layer of silicon formed over a substrate;

- forming a cobalt layer over the silicon layer;

- forming a TiN_x layer over the cobalt layer, wherein the TiN_x layer is formed by a sputtering process, a ratio of N₂ to Ar in a gas used in the sputtering process is approximately 3:1;

- performing a first thermal process to form a cobalt salicide layer over the silicon layer, the performing of the first thermal process including:

- diffusing cobalt into the silicon layer to form the cobalt salicide layer;

- diffusing nitrogen in the TiN_x layer into the cobalt salicide layer; and

- minimizing a diffusion of the Ti from the TiN_x layer into the silicon layer;

- removing any unreacted cobalt; and

- performing a second thermal process to reduce a resistance of cobalt salicide formed in the performing of the first thermal process.

Claim 17:

The method of claim 13, wherein the TiN_x layer is formed over the cobalt layer to a thickness in a range of approximately 25 angstroms to approximately 100 angstroms.

IX) EVIDENCE APPENDIX

None.

X) RELATED PROCEEDINGS APPENDIX

None.